IQRA NATIONAL UNIVERSITY
STEEL STRUCTURES

Final Term Examination
(Summer 2020)

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Dated = 29/09/2020

Date: 29/ 09/ 20

Q1:- Select the lightest - - - -
- - - - - - - - method.

Lightest W-shape column
A36 steel
DL = 60k L.L = 110k
Pin supported at top and bottom
$K_xL_x = 36ft$ $K_yl_y = 18ft$

AISC/LRFD method

Sol:-
Required Capacity = $(1.2 \times 60) + (1.6 \times 110)$
= 248k

Enter design strength table of manual with KL = 18ft and P = 248k

Some possible sections are

$W_{14 \times 61}$ P = 364 $r_x/r_y = 2.44$

$W_{12 \times 53}$ P = 320 $r_x/r_y = 2.11$

$W_{10 \times 49}$ P = 301 $r_x/r_y = 1.71$

$W_{8 \times 58}$ P = 300k $r_x/r_y = 1.74$

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Now

$$\frac{KxLx}{KyLy} = \frac{36}{18} = 2$$

Try $W_{12} \times 53$ $\quad r_x/r_y = 2.11$

$$r_x/r_y > \frac{KxLx}{KyLy}$$

$r_x = 5.23$ $\quad r_y = 2.48$ $\quad A = 15.6 in^2$

$$\frac{KxLx}{rx} = \frac{36 \times 12}{5.23} = 82.6$$

$$\frac{KyLy}{ry} = \frac{18 \times 12}{2.48} = 87.09$$

$$\frac{KL}{r} = 87.09$$

$$\lambda c = \frac{KL}{r\pi}\sqrt{\frac{Fy}{e}}$$

$$= \frac{87.09}{\pi}\sqrt{\frac{36}{29.000}}$$

$$= 0.97 < 1.5$$

$$Fcr = 0.658^{\lambda^2} \times Fy$$

$$= 0.658^{(0.97)^2} \times 36$$

$$Fcr = 24.28$$

$P_n = A_g F_{cr}$

$= 15.6 \times 24.28$

$P_n = 378.78k$

$\phi P_n = 0.85 \times 378.78$

$= 321.96 > 248\,k$

So use W12 x 53

Q2:- Determine the lightest - - - -

- - - - - - - - - - method.

-> Lightest W section

-> D.L = 1.5 k L.L = 4.5 k

(At each quater point)

-> Total length = 52'

-> Live load deflection = $\frac{1}{360}$ of span

-> $F_y = 36$ ksi

AISC/ASD method

Sol:-

Design load = 4.5+1.5 = 6 k

$P = 6k$

$$\Delta = \frac{5}{48} \frac{ML^2}{EI} \quad \text{——} \ (1)$$

Δ by this equation is multiplied by the factor from table 5.4

$$M = \left(\frac{3}{2} \times 6 \times 26\right) - \left(6 \times 13\right) = 156 k.ft$$

$$eq (1) \Rightarrow I = \frac{5}{48} \times \frac{ML^2}{E\Delta} \times 0.95$$

$$I = \frac{5}{48} \frac{(156 \times 12)(52 \times 12)^2}{29{,}000\left(\frac{52}{360} \times 12\right)}$$

$I = 1510.51 \ in^4$

Try W24x62 , $I_x = 1550 \ in^4$

$b_f = 7.04$ in = 5.72

$$L_c = \frac{76 b_f}{\sqrt{F_y}} \Rightarrow \frac{76 \times (7.04)}{\sqrt{36}} = 89'' = 7.41''$$

$$L_c = \frac{20{,}000}{f_y \frac{d}{A_f}} \Rightarrow \frac{20{,}000}{36 \times 5.72} = 97.12'' = 8.09'$$

$L > L_c$ from table 5.2

$C_b = 1.13$

Scanned with CamScanner

$$\sqrt{\frac{102,000 cb}{Fy}} = \sqrt{\frac{102,000 \times 1.13}{36}} = 57$$

$$\sqrt{\frac{510,000 cb}{Fy}} = \sqrt{\frac{510,000 \times 1.13}{36}} = 127$$

$$\frac{L}{rT} = \frac{13 \times 12}{1.71} = 91.22$$

Condition

$$\sqrt{\frac{102,000 cb}{Fy}} \leq \frac{L}{rT} \leq \sqrt{\frac{510,000 cb}{Fy}}$$

So,

$$Fb = \left[\frac{2}{3} - \frac{Fy\,(L/rT)^2}{1530 \times 10^3 \times cb}\right] Fy$$

$$= \left[\frac{2}{3} - \frac{36(91.22)^2}{1530 \times 10^3 \times 1.13}\right] 36$$

Fb = 17.76 ksi allowable.

The beam self weight

$= 62 \frac{lb}{ft} = 0.062 k/ft$

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$$M = \frac{WL^2}{8} = \frac{1}{8}(0.062)(52)^2$$

$M = 20.95$ kft

Total $M = 156 + 20.95$

$M = 176.95$

$S_n = 131$

$$f_b = \frac{M}{S_n} \Rightarrow \frac{176.95 \times 12}{131} = 16.2 \text{ ksi}$$

$f_b < F_b$

Use $W24 \times 62$

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Q3:- Determine an A-36 double - - - - - - - - - - - - - - ASD method.

Given

D.L = 50k
L.L = 150k
Bolts Dia = 3/4
Length = 18 ft

Connection type = Bearing
ASD method

Required:

Design A36 steel double angle tension member.

Sol:-

Total load = D.L + L.L
= 50+150
= 200k or 100k/Angle

-> For yielding at the gross area allowable stresses are

$0.6 F_y = 0.6 \times 36$
$= 22 ksi$

-> For Fracture at the net area allowable stresses are

$0.5 F_u = 0.5 \times 58 = 29 ksi$

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→ Since the connection is bolted so $A_g \neq A_n$

Now $A_e = 0.85 A_n$

For yielding

$$A_g \times 22 = 100$$

$$A_g = \frac{100}{22}$$

$$A_g = 4.54 \, in^2$$

For fracture

$$29 \times A_e = 100$$

$$A_e = 3.44 \, in^2$$

$$A_n = A_e / 0.85 \Rightarrow 3.44/0.85 \Rightarrow \boxed{A_n = 4.04 \, in^2}$$

→ Assume 15% deduction in gross area for holes.

So,

$$A_g = \frac{A_n}{0.85} \Rightarrow A_g = \frac{4.04}{0.85}$$

$$\boxed{A_g = 4.76 \, in^2}$$

For $L4 \times 4 \times \frac{5}{8}$ $A_g = 4.61 \cong 4.76$
$r_x = 1.20$ $r_y = 1.20$ with $\frac{3}{8}$ in Gusset plate

$$\frac{L}{r_{min}} = \frac{18 \times 12}{1.20} = 180 \leq 300k$$

Bolts Design

Using A325 bolts with threads included in shear plane as dia = 3/4"

$$Area = \frac{\pi}{4}(d)^2 \Rightarrow \frac{\pi}{4}(0.75)^2$$

$$\boxed{A = 0.441 in^2}$$

Allowable bolts shear = 21 ksi

Since bolts are in double shear so allowable shear per bolt
$= 2 \times 21 \times 0.44 = 18.5k$

Allowable bolt bearing stress $= 1.2 F_u$
$= 1.2 \times 58 = 69.6k$

Allowable bearing on two $\frac{5}{8}$" thick angle long legs $= 69.6 \times 2 \times \frac{5}{8} \times 0.75 = 65.25 > 18.5$

So shear gains.

Scanned with CamScanner

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No. of bolts = $\frac{200}{18.5}$ = 10.81

Use 10 bolts

Design of gusset plate

Bearing stress = 1.2 Fu
= 1.2 x 58 = 69.6 ksi

So
Allowable bearing = 69.6 x 10 x 0.75 x t = 200
t = 0.38 in

Use $\frac{3}{4}$" G.P

Checking various limit states
Yielding = 0.6 Fy Ag
= 0. 6 Fy Ag

= 0.6 x 36 x (8 x 0.75)
= 129.6k < 200k [Not ok]

Try L 7 x 4 x ½ Ag = 5.25

rx = 2.25 ry = 1.11 with $\frac{3}{8}$" G.P

$\frac{L}{r_{min}}$ = $\frac{18 \times 12}{1.11}$ = 194.59 ≤ 300k [ok]

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Allowable bearing on two $\frac{1}{2}$" thick angle long legs

$$= 69.6 \times 2 \times 1/2 \times 0.75$$

$$52.2 > 18.5$$

So shear gov
checking various Limit states
Yielding $= 0.6 F_y A_g$

$$= 0.6 \times 36 \times (14 \times 0.75)$$

$$= 226.8 > 200k \quad ok$$

Fracture $= 0.5 \times F_u \times A_e$

$$= 0.5 \times 58 \times 0.85 \left[14 - \left(\frac{3}{4}\right) \times 2\right] \times 3/4$$

$$= 231k > 200k \quad [ok]$$

Check for bearing failure

$$L_c = \frac{2P}{F_u t}$$

$$1.25 = \frac{2P}{58 \times 0.5}$$

$$(1.25)(58 \times 0.5) = 2P$$

$$P = 18.125k$$

$$L = \frac{2P}{F_u t} + \frac{d_n}{2}$$

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$$2 = \frac{2P}{58 \times 0.5} + \frac{3/4}{2}$$

$2(58 \times 0.5) = 2P + 0.375$

$116.1 - 0.375 = 2P$

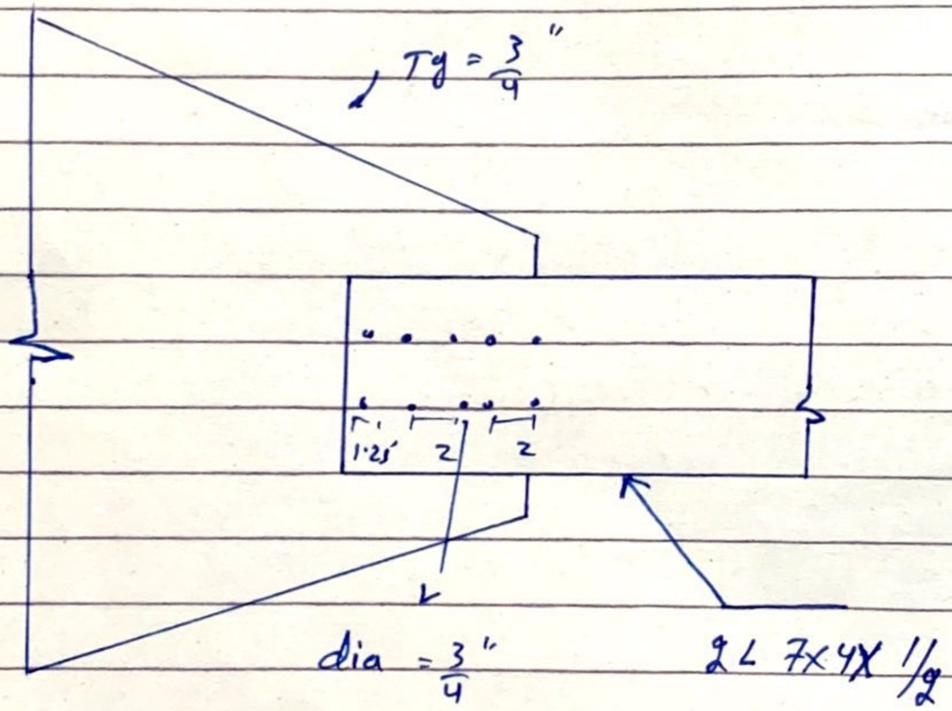
$115.72 = 2P$

$\boxed{P = 57.86k}$

Capacity: Since 10 bolts & five bolts per row

$2 \times 18.125 + 8 \times 57.86$

$499.13k > 200k$ [ok]



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